July 1963

U.S. FOREST SERVICE
RESEARCH NOTE RM - 2

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

An Analysis and Simplification of the Blaney-Criddle Method for Estimating Evapotranspiration

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Blaney and Criddle[2] developed a method for estimating evapotranspiration for different vegetation types, and their method has become widely known.[3,4] Their method was studied in preparation for comparative tests of a new method for direct measurement of evapotranspiration.[5] This preliminary study revealed that calculations for the Blaney-Criddle method can be simplified for some applications.

THE BLANEY-CRIDDLE METHOD

Evapotranspiration for a species in a locality is estimated as the measured loss for that species in another locality adjusted for a climatic factor. The underlying assumption is that evapotranspiration from land abundantly supplied with water and occupied by the species is directly proportional to the climatic factor (F) and is otherwise constant. The basic relationship is stated as $U = KF$, where U is consumptive use (evapotranspiration) for the period of estimate, F is the sum of monthly f's for that period (each f is a product of mean monthly temperature and total monthly daylight), and K is an empirical coefficient for that species.

The method for computing K is not entirely clear. On page 15[2] it is indicated that KF = sum of kf's and that kf = u. Thus, one could compute K as a sum of monthly k's, each of which was computed as $k = u/f$. This appears to be the only possible direct use of the expression kf. On page 17[2] however, it is stated that K was computed as $K = U/F$. At first glance the two K's appear identical, but they differ numerically because one is based on a sum of products and the other on a product of sums. If the latter procedure is followed, the quantities k and kf need not be introduced. The apparent ambiguity need not be resolved, because direct computation of K is not essential to estimate consumptive use.

SIMPLIFIED METHOD

The simplified method depends on the same assumption and on the same data as the original method. That is, evapotranspiration from land abundantly supplied with water and occupied by a given species is assumed to be di-

rectly proportional to the climatic factor F and is otherwise constant. As before, this relationship can be stated as $U = KF$. For a known locality let $U_1 = KF_1$. For the locality of estimate let $U_2 = KF_2$ Now, after noting that $U_1/F_1 = K$ and that $U_2/F_2 = K$, a statement $U_1/F_1 = U_2/F_2$ can be made, and the estimating equation becomes

$$U_2 = \frac{F_2 U_1}{F_1}.$$

Use of K is not necessary to transform any data to arrive at this final statement. The remaining question is whether it is convenient. In the original method, one looks up F_2 and K and carries out a one-step computation: $K \times F_2 = U_2$. In the simplified method, one looks up U_1, F_1, and F_2 and carries out a two-step computation:

$$\frac{U_1 F_2}{F_1} = U_2.$$ If one were making many such estimates and had appropriate K's already computed, the original system might save time. If one made such estimates only occasionally, however, the time saved by avoiding one arithmetical step (division) would probably be less than the time required to relearn nomenclature.

COMMON WEAKNESS OF BOTH METHODS

Both methods assume the ratio U_1/F_1 to be constant for a species. Table 15 of Blaney and Criddle[2] show that values range as follows: alfalfa 0.93 - 0.77, corn 0.96 - 0.45, cotton 0.63 - 0.45. The wide ranges for a species indicate that not all variability of evapotranspiration, even for land areas occupied by a cultivated species, can be accounted for by mean monthly temperatures and day lengths. The assumption may be even less valid with natural stands of wild species, because a wider range of stocking density can be expected here, and evapotranspiration has been shown to vary greatly with density of stocking.[5] Although the methods offer promise, more data are required than are currently accessible in the professional literature before the constancy of the ratio--and therefore the reliability of the methods--can be realistically appraised.

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[2]*Blaney, H. F., and Criddle, W. D. Determining water requirements in irrigated areas from climatological and irrigation data. USDA SCS-TP-96. 48 pp., illus. 1952.*

[3]*Penman, H. L. Estimating evaporation. Amer. Geophys. Union Trans. 37: 43-50. 1956.*

[4]*Tanner, C. B., and Pelton, W. L. Potential evapotranspiration estimates by the approximate energy balance method of Penman. Jour. Geophys. Res. 65: 3391-3413. 1960.*

[5]*Decker, J. P., Gaylor, W. G. and Cole, F. D. Measuring transpiration of undisturbed tamarisk shrubs. Plant Physiol. 37: 393-397, illus. 1962.*